Claims

I claim:

1. A bipolar plate for a fuel cell stack comprising:

a semi-conductive body having a first face adapted to contact an anode of a first fuel cell and a second face adapted to contact a cathode of a second fuel cell, the first face comprising a first flow channel adapted to confine fuel fluids, and the second face comprising a second flow channel adapted to confine oxidizing fluids.

2. The bipolar plate as defined in claim 1 wherein the bipolar plate has a thickness ranging from about 50 microns to about 2,000 microns.

3. The bipolar plate as defined in claim 1 wherein the bipolar plate has a thickness ranging from about 500 microns to about 1,000 microns.

4. The bipolar plate as defined in claim 1 wherein at least one of the flow channels has a width ranging from about 1 micron to about 5,000 microns.

5. The bipolar plate as defined in claim 1 wherein at least one of the flow channels has a width ranging from about 20 microns to about 500 microns.

6. The bipolar plate as defined in claim 1 wherein at least one of the flow channels has a depth ranging from about 1 micron to about 3,000 microns.

7. The bipolar plate as defined in claim 1 wherein at least one of the flow channels has a depth ranging from about 5 microns to about 500 microns.

8. 1The bipolar plate as defined in claim 1 wherein the semi-conductive body is selected from the group consisting of the Group IV semiconductors, the Group III-V semiconductors, and the Group II-VI semiconductors.

9. The bipolar plate as defined in claim 8 wherein the semi-conductive body is a doped semiconductor.

10. The bipolar plate as defined in claim 1 wherein the semi-conductive body is silicon.

11. The bipolar plate as defined in claim 1 wherein the first flow channel is further coated with a reforming catalyst or catalytic combuster.

12. The bipolar plate as defined in claim 11 wherein the reforming catalyst is selected from the group consisting of platinum, ruthenium, rhodium, nickel, cerium, iron, chromium, cobalt, manganese, copper, aluminum, oxides thereof, and mixtures thereof.

13. The bipolar plate as defined in claim 1, the bipolar plate further comprising a conduit therethrough.

14. The bipolar plate as defined in claim 13 wherein the conduit is adapted to receive a cooling fluid or a heating fluid.

15. The bipolar plate as defined in claim 14, the bipolar plate further comprising a recuperative heat exchanger.

16. The bipolar plate as defined in claim 13 wherein the conduit is further coated with a reforming catalyst or catalytic combuster.

17. The bipolar plate as defined in claim 1, the bipolar plate further comprising a resistive element located within the bulk of the bipolar plate or on the surface of the bipolar plate and adapted to heat the bipolar plate.

18. The bipolar plate as defined in claim 17 wherein the resistive element is selected from the group consisting of thin film resistive elements, thick film resistive elements, and diffused resistors.

19. The bipolar plate as defined in claim 17 wherein the resistive element comprises a material selected from the group consisting of doped silicon, nickel, chromium, tantalum, aluminum, molybdenum, tungsten, titanium, palladium, platinum, silicides thereof, oxides thereof, and mixtures thereof.

20. The bipolar plate as defined in claim 1, the bipolar plate further comprising a sensor located within the bulk of the bipolar plate or on the surface of the bipolar plate.

21. The bipolar plate as defined in claim 20, wherein the sensor is selected from the group consisting of mechanical, thermal, magnetic, electrical, chemical, and radiation sensors.

22. The bipolar plate as defined in claim 20 wherein the sensor is selected from the group consisting of pressure, temperature, voltage, and flow sensors.

23. The bipolar plate as defined in claim 21 wherein the chemical sensor is selected from the group consisting of hydrogen ion, hydrogen, oxygen, water, hydrogen peroxide, carbon monoxide, carbon dioxide, sulfur, sulfur oxide, methanol, ethanol, methane, ethane, butane, propane, and pentane sensors.

24. A bipolar plate for a fuel cell stack comprising:

a conductive body having a first face adapted to contact an anode of a first fuel cell and a second face adapted to contact a cathode of a second fuel cell, the first face comprising a first flow channel adapted to confine fuel fluids, the second face comprising a second flow channel adapted to confine oxidizing fluids; and

a sensor located within the bulk of the bipolar plate or on the surface of the bipolar plate.

25. The bipolar plate as defined in claim 24 wherein the conductive body is selected from the group consisting of graphite, stainless steel, nickel, iron, chrome, tungsten, cobalt, titanium, and alloys thereof.

26. The bipolar plate as defined in claim 24 wherein the first flow channel is further coated with a reforming catalyst.

27. The bipolar plate as defined in claim 24, the bipolar plate further comprising a conduit therethrough.

28. The bipolar plate as defined in claim 27 wherein the conduit is adapted to receive a cooling fluid or a heating fluid

29. The bipolar plate as defined in claim 27 wherein the conduit is further coated with a reforming catalyst or catalytic combuster.

30. The bipolar plate as defined in claim 24, the bipolar plate further comprising a resistive element located within the bulk of the bipolar plate or on the surface of the bipolar plate and adapted to heat the bipolar plate.

31. A bipolar plate for a fuel cell stack comprising:

a conductive body having a first face adapted to contact an anode of a first fuel cell and a second face adapted to contact a cathode of a second fuel cell, the first face comprising a first flow channel adapted to confine fuel fluids, the second face comprising a second flow channel adapted to confine oxidizing fluids, wherein the first flow channel is further coated with a reforming catalyst.

32. A bipolar plate for a fuel cell stack comprising:

a conductive body having a first face adapted to contact an anode of a first fuel cell and a second face adapted to contact a cathode of a second fuel cell, the first face comprising a first flow channel adapted to confine fuel fluids, the second face comprising a second flow channel adapted to confine oxidizing fluids; and

a conduit therethrough adapted to receive cooling or heating fluid.

33. A bipolar plate for a fuel cell stack comprising:

a conductive body having a first face adapted to contact an anode of a first fuel cell and a second face adapted to contact a cathode of a second fuel cell, the first face comprising a first flow channel adapted to confine fuel fluids, the second face comprising a second flow channel adapted to confine oxidizing fluids; and

a conduit therethrough coated with a reforming catalyst.

34. A bipolar plate for a fuel cell stack comprising:

a conductive body having a first face adapted to contact an anode of a first fuel cell and a second face adapted to contact a cathode of a second fuel cell, the first face comprising a first flow channel adapted to confine fuel fluids, the second face comprising a second flow channel adapted to confine oxidizing fluids; and

a resistive element located within the bulk of the bipolar plate or on the surface of the bipolar plate and adapted to heat the bipolar plate

35. A method of making a bipolar plate for a fuel cell stack, the method comprising steps of:

providing a semi-conductive or conductive substrate having a first face and a second face;

etching a first flow channel from the first face; and

etching a second flow channel from the second face.

36. The method as defined in claim 35 wherein the substrate is selected from the group consisting of semiconductors, graphite, and metals.

37. The method as defined in claim 35 wherein the step of etching is performed using an etchant selected from the group consisting of wet anisotropic etchants, wet isotropic etchants, plasma anisotropic etchants, plasma isotropic etchants, and combinations thereof.

38. The method as defined in claim 35, the method further comprising the step of applying a mask to the first or second face of the substrate before the step of etching a flow channel from the masked face.

39. The method as defined in claim 38, the method further comprising the step of patterning the mask by photolithography before the step of etching the flow channel from the first or second face.

40. The method as defined in claim 35, further comprising the step of coating the first channel with a reforming catalyst.

41. The method as defined in claim 40 wherein the step of coating the first flow channel with a reforming catalyst is performed by a coating method selected from the group consisting of sputter deposition, chemical vapor deposition, evaporation, electroplating, solution deposition, and combinations thereof.

42. The method as defined in claim 35, further comprising the step of creating a conduit wherein the conduit passes through the substrate.

43. The method as defined in claim 42 wherein the step of creating a conduit is performed by etching or a combination of etching and bonding.

44. The method as defined in claim 42 wherein the step of creating a conduit is performed by a method selected from the group consisting of drilling, abrasive machining, laser machining, and laser ablation.

45. The method as defined in claim 42, further comprising the step of coating the conduit with a reforming catalyst.

46. The method as defined in claim 35, further comprising the step of creating a resistive element wherein the resistive element is located within the bulk of the bipolar plate or on the surface of the bipolar plate and is adapted to heat the bipolar plate.

47. The method as defined in claim 45 wherein the step of creating the resistive element is performed by a combination of one or more methods selected from the group consisting of photolithography, wet etching, plasma etching, ion implantation, high temperature diffusion, boron concentration dependent etching, electrochemical etching, bonding, lift off, spin coating, dip coating, sputter deposition, evaporation, electroplating, solution deposition, and chemical vapor deposition.

48. The method as defined in claim 35, further comprising the step of micromachining a sensor from the bulk of the substrate or micromachining a sensor on the surface of the substrate.

49. The method as defined in claim 48 wherein the step of micromachining is performed by a combination of one or more methods selected from the group consisting of photolithography, wet etching, plasma etching, boron concentration dependent etching, electrochemical etching, bonding, lift off, spin coating, dip coating, sputter deposition, evaporation, electroplating, solution deposition, and chemical vapor deposition.

50. An end plate for a fuel cell stack comprising:

a semi-conductive body having a first face adapted to collect current and a second face adapted to contact an electrode of the fuel cell, the first face having a substantially planar surface, and the second face comprising an etched flow channel adapted to confine fluids.

51. The end plate of claim 50, the end plate further comprising a sensor located within the bulk of the end plate or on the surface of the end plate.

52. The end plate of claim 50, the end plate further comprising a resistive element located within the bulk of the end plate or on the surface of the end plate and adapted to heat the end plate.

53. An end plate for a fuel cell stack comprising:

a conductive body having a first face adapted to collect current and a second face adapted to contact an electrode of the fuel cell, the first face having a substantially planar surface, and the second face comprising an etched flow channel adapted to confine fluids; and

a sensor located within the bulk of the end plate or on the surface of the end plate.

54. The end plate of claim 53, the end plate further comprising a resistive element located within the bulk of the end plate or on the surface of the end plate and adapted to heat the end plate.

55. A method of making an end plate for a fuel cell stack, the method comprising steps of:

providing a substantially planar semi-conductive or conductive substrate having a face; and

etching a flow channel from the face.

56. A fuel cell stack comprising:

a plurality of fuel cells, each fuel cell comprising a cathode, an anode, and an electrolyte arranged between the cathode and anode;

bipolar plates arranged between the fuel cells, each bipolar plate comprising a semi-conductive body having a first face adapted to contact the anode of a fuel cell and a second face adapted to contact the cathode of a fuel cell, the first face comprising a first flow channel adapted to confine fuel fluids, and the second face comprising a second flow channel adapted to confine oxidizing fluids; and

end plates, each end plate comprising a semi-conductive or conductive body having a first face adapted to collect current and a second face adapted to contact an electrode of a fuel cell, the first face having a substantially planar surface, and the second face comprising a flow channel adapted to confine fluids.

57. A method of making a fuel cell stack comprising steps of:

providing a plurality of fuel cells;

providing a plurality of bipolar plates according to claim 1;

assembling the fuel cells and bipolar plates alternately to form a stack;

providing end plates; and

completing the stack with the end plates.

58. An electronic device comprising a fuel cell stack according to claim 56.